

# Poliovirus Neutralizing Antibody Levels Among Preschool Children

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THE MARKED DECLINE in the incidence of paralytic poliomyelitis in the past decade has been attributed to the extensive use of available vaccines. An inactivated trivalent poliovirus vaccine (IPV) became available for general use in the United States in 1955, followed in 1961 by orally administered attenuated live poliovirus vaccine (OPV).

Although both vaccines have been used extensively, surveys have indicated that certain groups of persons, particularly in lower socioeconomic areas, have low levels of immunization. A 1966 nationwide survey conducted by the National Communicable Disease Center, Public Health Service, revealed that one-fifth of non-white children under 5 years of age had received no poliovirus vaccines (1).

Such a survey, however useful in providing an estimate of the proportion of children who have been immunized, does not provide information on the actual status of natural or induced

antibodies of the populations considered. For this reason our study assessed prevalence of neutralizing antibodies to polioviruses in selected population groups in Greater Kansas City.

Serosurveys conducted in July 1966 on 110 children in a Kansas City, Mo., housing project and in 1965 and 1966 on three smaller groups of children from Greater Kansas City provided the study data. According to their medical histories, one-fifth of the children from families in low socioeconomic groups had received no poliovaccine and only half had been adequately immunized. Neutralizing antibodies to each of three polioviruses were demonstrated in 65-85 percent of the children in the principal survey population.

## Methods

*Principal survey population.* The two criteria used in selecting the principal survey population (population A) were that the children be from families of low socioeconomic status and that there had been no special efforts to distribute poliovirus vaccines to them other than those made in the entire metropolitan area. Since a poliomyelitis epidemic had occurred in the low socioeconomic areas of Kansas City, Mo., in 1959 (2), only persons 6 years of age or under were sampled to avoid testing children with naturally acquired immunity. It was of

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note that the community chosen for this survey had been involved in the 1959 epidemic.

Serums and immunization histories were obtained by two teams, each consisting of a physician, nurse, and clerk. Plans were made to obtain at least 100 serums, and by soliciting door to door on a nonrandom basis serums were obtained from 110 children. Of 52 nonwhite families visited, 50 cooperated with the teams.

*Comparative population groups.* Serums from three additional groups of 1- to 6-year-old children were also tested. Two of these groups (populations B and C) were of low socioeconomic level, and one (population D) was middle socioeconomic level. Population B was 37 white and nonwhite children who came or accompanied a child who came to the Kansas City, Kans., health department during the summer of 1966 for mandatory preschool tuberculin skin tests, thus avoiding a population of children coming primarily for immunizations.

Population C was 20 white and nonwhite children who had been participants in a study of acute respiratory disease among clinic patients at a local hospital in 1965. Population D was 28 white children who participated in a November 1965 survey to determine the prevalence of enterovirus and arbovirus antibodies in residents of Hickman Mills, Mo., a suburb of Kansas City. A history of poliomyelitis immunization among children in populations B and D was obtained; such data were not collected for population C.

All serums were tested for specific neutralizing antibodies to poliovirus types I, II, and III by the microtiter plate technique (3) using secondary monkey kidney tissue cultures. Titra-

**Table 2. Percent distribution of neutralizing antibodies to polioviruses, population A, Kansas City, Mo., July 1966**

Age group (years)	Number children	Percent with antibody titers $\geq 1:8$ to—			
		No types	1 type	2 types	All 3 types
1-2-----	38	11	18	32	39
3-4-----	34	12	0	32	56
5-6-----	38	3	8	26	63
Total.....	110	8	9	30	53

tions were determined using 30-100 TCID<sub>50</sub> of poliovirus types I (Brunhilde strain), II (MEF-1 strain), and III (Saukett strain).

### Results

In January 1966 the Kansas City, Mo., housing authority conducted a census in the housing project in which the principal survey population (A) resided. Of 1,650 residents, 353 were under age 6 and 615 were 6-13 years of age. Serum samples were taken from 26 percent of children under age 6 for this study.

Eighty-one percent of the survey population had received at least one dose of poliovirus vaccine; however, only 58 percent of the 1- and 2-year-olds had received one or more doses of vaccine (table 1). The minimum criteria for adequate immunization is 2 doses of OPV or 3 doses of IPV or IPV and OPV. Only 56 percent of the children were considered adequately immunized; 19 percent were unvaccinated and 25 percent had an inadequate number of doses (table 1). None of the children had received

**Table 1. Immunization history of population A, Kansas City, Mo., July 1966**

Age group (years)	Number children	Children immunized <sup>1</sup>		Percent receiving—		
		Number	Percent	No vaccine	Inadequate doses <sup>2</sup>	Adequate doses <sup>3</sup>
1-2-----	38	22	58	42	32	26
3-4-----	34	30	88	12	26	62
5-6-----	38	37	97	3	18	79
Total.....	110	89	81	19	25	56

<sup>1</sup> At least 1 dose of inactivated trivalent poliovirus vaccine (IPV) or 1 dose of orally administered attenuated live poliovirus vaccine (OPV).

<sup>2</sup>  $\leq 3$  IPV,  $< 2$  OPV, or no IPV and OPV.

<sup>3</sup>  $\geq 3$  IPV,  $\geq 2$  OPV, or IPV and OPV.

**Table 3. Distribution of neutralizing antibodies to polioviruses, population A, Kansas City, Mo., July 1966**

Age group (years)	Number children	Percent with antibodies to poliovirus—		
		I	II	III
1-2-----	38	71	71	61
3-4-----	34	76	88	68
5-6-----	38	87	97	66
Total-----	110	78	85	65

three doses of oral vaccine, perhaps because a two-dose regimen of trivalent vaccine was used in the citywide "Sabin on Sunday" campaign conducted a year before the survey.

Table 2 shows the percent of children in each age group with neutralizing antibody titers  $\geq 1:8$  to any or all three types of polioviruses. Subsequently, the term antibodies will be used for neutralizing antibody titers  $\geq 1:8$ . Fifty-three percent of the children in the survey population A had antibodies to all three types, 83 percent to at least two types, and 92 percent to at least one type of poliovirus. Only 39 percent of the 1- and 2-year-old children had antibodies to all three types of poliovirus.

Of 21 children giving a history of no immunization, 29 percent were seronegative to all three polioviruses, and nearly half had antibodies to at least two types. Among children who had received at least some immunization, only 3-4 percent were seronegative to all three polioviruses.

About two-thirds of the children had antibodies to type III poliovirus, 85 percent had antibodies to type II, and 78 percent had antibodies to type I (table 3). Twenty-nine percent or more of 1- and 2-year-olds had no antibodies to each of the polioviruses.

No consistent trend in the proportion of children with antibodies was demonstrated when comparing persons with histories of adequate immunization to those with histories of inadequate immunization (table 4). Therefore, these data are summarized disregarding the number of doses and comparing only the kinds of vaccine reportedly received to minimum titers achieved to each of the three polioviruses (see chart). Of the children with a history of no

immunization, 57 percent had antibodies  $\geq 1:8$  to poliovirus type II, 48 percent to type I, and 29 percent to type III. The percentage of immunized children with antibodies to each poliovirus was highest among those who had received IPV plus OPV and the lowest among those with IPV only.

Although there is some variation in the percentage of children in the three low socioeconomic groups (A, B, and C) with antibodies to specific polioviruses, the patterns are similar (table 5). This trend is decidedly different from that observed among the children from the middle socioeconomic families (population D), all of whom had antibodies to poliovirus type II and 86 percent of whom had antibodies to types I and III. Of these children in the middle socioeconomic group, 93 percent had antibodies to at least two poliovirus types and 79 percent had antibodies to all three types. Only one child from this economic group had a history of inadequate immunization.

Fifty-two percent of the 147 children in the low socioeconomic groups from which samples were taken in summer 1966 (populations A and B) had high titers ( $\geq 1:128$ ) to poliovirus type II. The majority of these children had titers in the middle to low range ( $\leq 1:64$ ) for types I and III (table 6).

### Discussion

A "Sabin on Sunday" two-dose campaign using trivalent vaccine was conducted in Greater Kansas City in March and May 1965. Approxi-

**Table 4. Percent of population A with antibodies to the polioviruses by immunization history, Kansas City, Mo., July 1966**

Immunizations received	Number children	Percent with antibodies to poliovirus—		
		I	II	III
IPV:				
Inadequate <sup>1</sup> -----	9	67	78	67
Adequate <sup>2</sup> -----	9	78	89	56
OPV:				
Inadequate <sup>3</sup> -----	19	95	84	68
Adequate <sup>4</sup> -----	21	76	95	71

<sup>1</sup> 1 or 2 injections.

<sup>2</sup> 3 or more injections.

<sup>3</sup> 1 dose trivalent.

<sup>4</sup> 2 or more doses trivalent.

mately 50,000 doses were given each month, and 2,500 doses were given in a smaller makeup clinic in October 1965. This was the first communitywide campaign in Metropolitan Kansas City using the oral vaccine. No estimates were available as to how effective the program was in reaching persons in lower socioeconomic areas. Our serosurvey was conducted among children in two low socioeconomic areas about 1 year after the OPV campaign and among children in a middle socioeconomic area about 6 months after the campaign.

Our data suggest that children in the low socioeconomic groups are most vulnerable to poliomyelitis and an outbreak of this disease might occur if virulent poliovirus were introduced into the area. The 56 percent of nonwhite children in the low socioeconomic population A who had been adequately immunized in 1966 was considerably greater than the 11 percent reported among similar Kansas City populations by Chin and Marine (4) in 1959.

The current immunity status as measured by serum neutralizing antibodies suggests a major outbreak similar to that of 1959 would be unlikely, but there are several disconcerting facts. The most important of these is that despite a widely publicized vaccination campaign 1 year earlier, the extent of seroimmunity detected could not be considered satisfactory since immunity to each of the three polioviruses was demonstrated in only 60-70 percent of the 1- and 2-year-olds.

Since approximately one-third of the children in the low socioeconomic groups were immunologically susceptible to poliovirus types I and III, it is conceivable that these agents, once introduced, could spread and result in several

**Table 6. Ranges of poliovirus neutralizing antibody titers among 147 preschool children in populations A and B, Greater Kansas City, July 1966**

Poliovirus type	Percent with neutralizing titer <sup>1</sup> of—				
	<8	8-16	32-64	128-256	≥512
I-----	28	24	28	13	7
II-----	14	8	26	36	16
III-----	36	31	24	6	3

<sup>1</sup> Reciprocal of serum dilution.

cases of paralytic illness. In communities where intensive immunization campaigns have not been conducted in recent years the proportion of susceptible children is probably greater than that reported here.

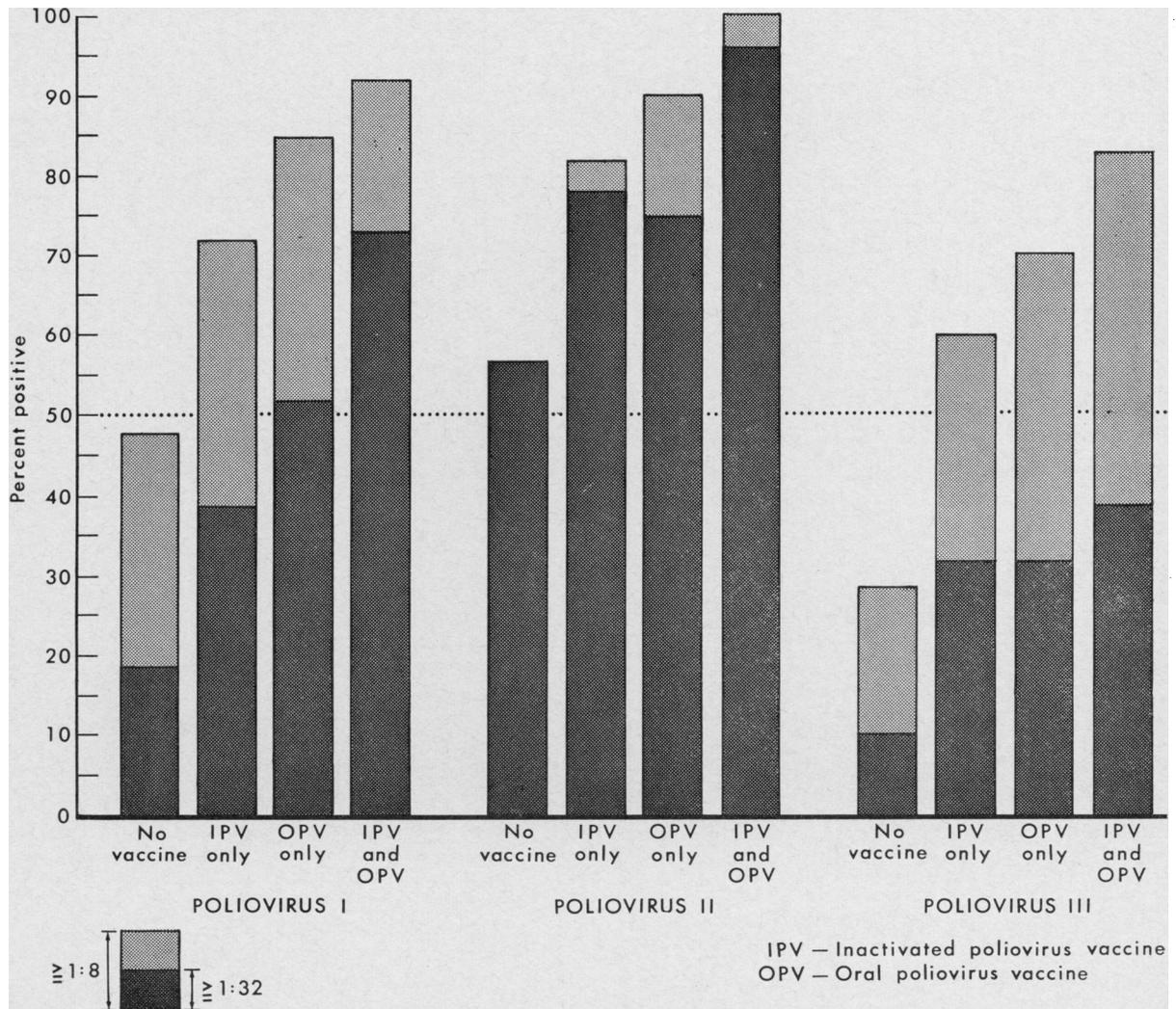
Findings of the 1966 NCDC immunization survey (1) show that 10 percent of white children and 21 percent of nonwhite children under 5 years of age had received no poliovaccine. In our study group (population A) 28 percent of the nonwhite children under age 5 had received no poliovaccine, but this difference may be because the NCDC survey included many nonwhite families which were not in a low socioeconomic group or because of chance variation since our survey sample was smaller than theirs. The first explanation further supports the thesis that children in low socioeconomic families are poorly immunized against poliomyelitis. The accuracy of the immunization histories in the NCDC survey is probably comparable to ours, even though those data were not obtained by paramedical personnel.

Among children in the middle socioeconomic group, 86 percent had antibodies to poliovirus

**Table 5. Prevalence of neutralizing antibodies to polioviruses among children 1-6 years old in four population groups, Greater Kansas City, 1965-66**

Population	Socio-economic status	Number children	Percent negative to all 3 types	Percent with antibodies ≥ 1:8 to—		
				Polio-virus I	Polio-virus II	Polio-virus III
A—Survey—Kansas City, Mo., 1966-----	Low-----	110	8	78	85	65
B—Kansas City, Kans., 1966-----	Low-----	37	14	51	86	62
C—Greater Kansas City, 1964-65-----	Low-----	20	10	60	90	55
D—Hickman Mills, Mo., 1965-----	Middle-----	28	0	86	100	86

**Percent distribution of preschool children in a low socioeconomic group (population A) as related to immunization history, Kansas City, Mo., 1966**



types I and III, while 96 percent of these children gave a history of adequate immunization. These results are comparable to those of Lepow and associates (5) who found that 3 months after a campaign using monovalent OPV, 92-94 percent of 1- to 4-year-olds in middle socioeconomic groups had antibodies to poliovirus types I and III.

Significantly, immunization histories of these persons can provide only a crude estimate of the immunity status as compared to the data provided by serum neutralization antibody studies. This is undoubtedly because of inaccuracies in recollection by the parent, as well as

biological variations in the vaccine-host interaction. Although many of the immunization histories obtained by the study teams were from health department record cards carried by parents, the information recorded on many cards had been given to health department officials by parents and was not always information recorded at immunization.

When antibodies to poliovirus are found in children with no history of immunization, the explanation may be that an inaccurate history was given or that the child was infected by either vaccine virus (contact with a vaccinee) or naturally occurring virus. The fact that no

consistent trend was found between the proportions of children with antibodies who reported having adequate and inadequate immunizations also suggests that many of the histories were inaccurate.

This resulted in one of the principal difficulties encountered in this study, our inability to correlate demonstrable antibodies with the finer details of the number and kinds of vaccine doses reportedly received. Also, the unsatisfactory definition of two OPV doses as adequate was based on the fact that this was all that was recommended and given during the drive 1 year before this survey; none of the children in low socioeconomic population A had received more than two doses of OPV. The findings might have been quite different had a third dose of trivalent OPV been given.

### Summary

Serosurveys in Greater Kansas City involved a principal population group of 110 children from a low socioeconomic housing project (population A) and three smaller comparative populations. The comparative populations were a group of 37 children (population B) from a different low socioeconomic area sampled at the same time as population A, and a group of 20 children from low socioeconomic families (population C) and 28 children from a middle socioeconomic area (population D), both sampled 1 year earlier.

Of the 110 children in population A, about one-fifth were reported as unvaccinated and 45 percent as either not immunized or inadequately immunized. The minimum criteria for adequate immunization were two doses of oral attenuated live vaccine (OPV) or three doses of inactivated trivalent vaccine (IPV) or IPV plus OPV.

One-tenth of these children were seronegative to all three polioviruses.

Overall seroimmunity to the individual polioviruses as measured by neutralizing antibodies varied from 65 to 85 percent; the lowest rates were to type III and the highest to type II. More than a fourth of the children under age 3 had no detectable antibodies to each of the three polioviruses. Results were similar for populations B and C, but a considerably greater percent of children in the middle socioeconomic population D had antibodies to the polioviruses.

Even with the levels of seroimmunity demonstrated among low socioeconomic groups, an extensive outbreak of poliomyelitis is not likely to occur. However, if a virulent poliovirus were introduced into such a population, sporadic cases or even limited outbreaks of poliomyelitis could be expected, particularly among children under 3 years old.

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